Management of the Witsand primary aquifer: Northern Cape

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ABSTRACT

Witsand Nature Reserve is situated 70km from Postmasburg, just west of the Langberg Mountain Range on route from Griquatown to Groblershoop, in the Northern Cape. An area of flowing white dunes, 9 km long and 4 km wide, Witsand derived its name after the white sand of the dunes, which is in total contrast against the surrounding red Kalahari sands.

The Witsand aquifer is situated in the white sand dunes between quartzite outcrops of the Matsap formation. The great significance and importance of this aquifer is because of the supply of fresh ground water from the white dunes system to the Witsand Nature Reserve and adjacent farmers. A number of water pools are found in the hollows between the white sand dunes or water may be found with little effort by digging shallow holes in the sand. The average groundwater level in the dunes systems is 2m below surface and drop to 90m below surface in the surrounding red Kalahari sands.

Through extensive monitoring and close working relationships between the Nature Reserve, Farmers and Dept of Water Affairs the sustainability and quality of the resource is ensured.

The aim of the paper is to show a success story for groundwater management and optimal use in an arid region. The paper will focus on the background, monitoring, maintenance and management of the resource.

Keywords: *Witsand, Aquifer, Groundwater, Monitoring**.***

1. INTRODUCTION

Witsand was proclaimed as a Nature Reserve in April 1994, after the purchase of a large portion of the land in 1993. Since the proclamation of the Reserve 10 years ago the natural status of the dunes, fauna and flora has shown dramatic improvement and the Reserve is a big asset to the preservation of South Africa's natural heritage. The water use and management of the groundwater resource was implemented from the start and was maintained continuously to attribute to the sustainability of the resource today.

2. GEOGRAPHY

2.1 Topography

The topography of Witsand comprises a combination of linear and parabolic dunes, surrounded by plains covered in red Kalahari sand at about 1280m above sea level. The dunes are 9km long in a NE – SW direction and approximately 4km wide from the furthest boundary west to the furthest boundary east. To the east the Langberg mountain range rises to a level of 1660m above sea level and stretches from Waterford farm next to the R64 road in the South to 30km North of Olifantshoek in the North. Witsand is situated 70km from Postmasburg, just west of the Langberg on route from Griquatown to Groblershoop. (See figure 1 for location)

Figure 1. Location of Witsand

2.2 Climate

Witsand has a continental climate and is a summer rainfall region with an average rainfall of 290mm/annum. Most of the rainfall is in the form of thunderstorms. Average daily temperatures vary from 11°C in winter to 27°C in summer and the temperature can rise to a maximum of 48°C during January and February. See figure 2 for the average and annual rainfall over the past 10 years.

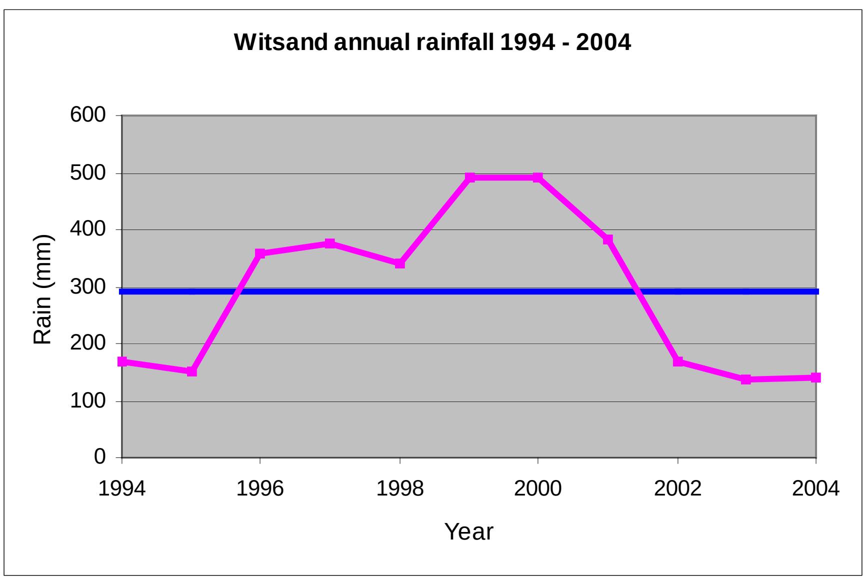

Figure 2. Witsand annual rainfall vs. average rainfall

3. GEOLOGY

The base rock is of Mogolium age from the Griqualand West Sequence overlain by white sand and wind-blown red sand of Quaternary age. The Top Dog Member of the Matsap formation, which consists of Quartzite, Conglomerate and sub Graywack, is present in the study area. (See figure 3 for geology)

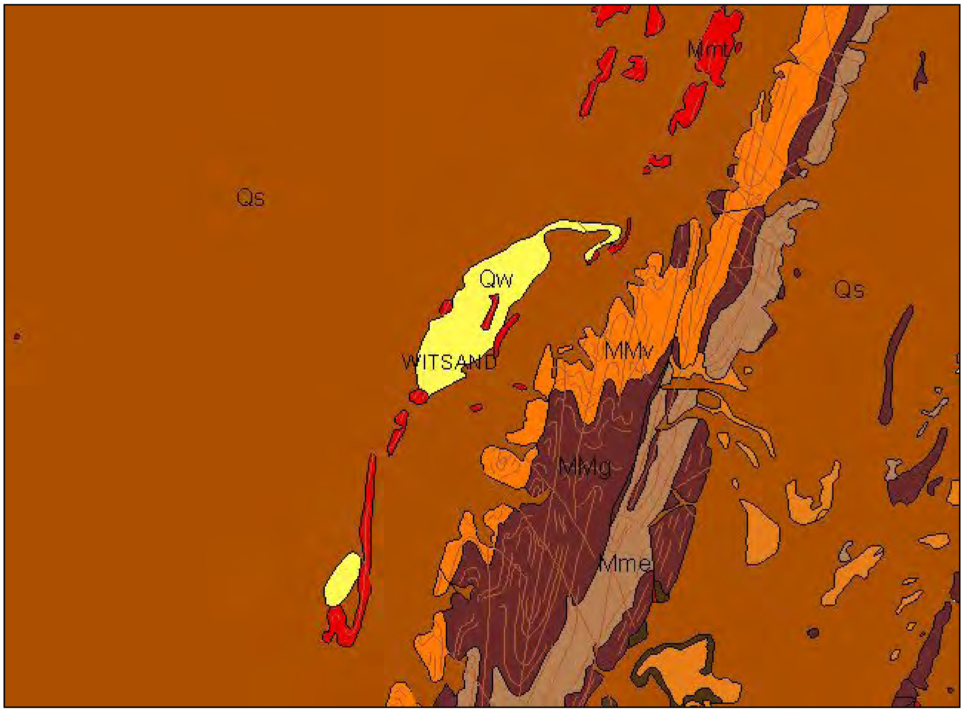

Figure 3. Geology of Witsand

Legend

Qw	White to flesh colored sand
Qs	Red to Flesh colored wind-blown sand
Mmt	White, gray and rose colored quartzite with subordinate brown sub greywacke
Mmv	Gray and white quartzite with lenses of hematite
Mmg	Gray and brown coarse grained sub greywacke and conglomerate
Mme	Alternating layers of gray and purple quartzite and brown sub greywacke

4. GEOHYDROLOGY

The type of aquifer is a primary aquifer, underlain by the quartzite base rock that forms a basin in which the aquifer occurs. The area of the aquifer is approximately 1 400 ha.

The water table in the white dune area is approximately 2m deep and a perennial artesian fountain – also known as Pepler's hole - is centrally situated within the white dune area. The quality of the groundwater is very fresh and correlates well with that of rainwater. The average water table of the immediate surrounding area is 90m deep and in a borehole 1km west of the fountain the water level is 270m deep.

During recent borehole clean–up and pumping tests the following parameters were obtained from boreholes G42453, G45711, G45712 close to the camp site. (See figure 10 for location of boreholes) The T-late and sustainable Q values were obtained by making use of the FC method and the S value by using the RPTSOLV program.

Table 1. Borehole parameters from pumping tests

Borehole	T- late	S value	Sustainable Q
G 42453	$247m^2/d$	3.000E-3	1.75 l/s
G45711	$223m^2/d$	3.000E-3	1.50 l/s
G45712	$482m^2/d$	3.000E-3	1.70 l/s

The high T-values are a result of borehole development and the construction of the borehole and not necessarily an indication of the T-value of the aquifer. The production boreholes are all equipped with Johnson screens and a gravel pack. Figure 4 represents a schematic presentation of the borehole construction.

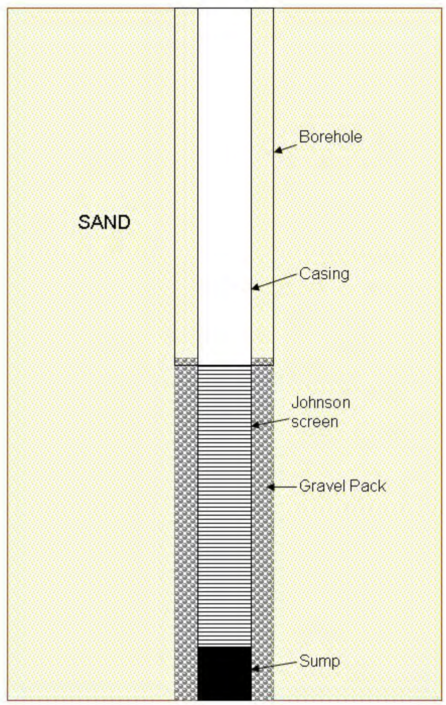

Figure 4. Schematic presentation of borehole construction

Water Quality

As previously mentioned the water quality at Witsand is very good. The following set of graphs give an indication of the groundwater quality at station ZQMWSD1 over time. The ZQMWSD1 station is part of a national groundwater quality-monitoring network. The pH values in figure 5 falls within the normal water quality standard and tends to be slightly more basic than acidic.

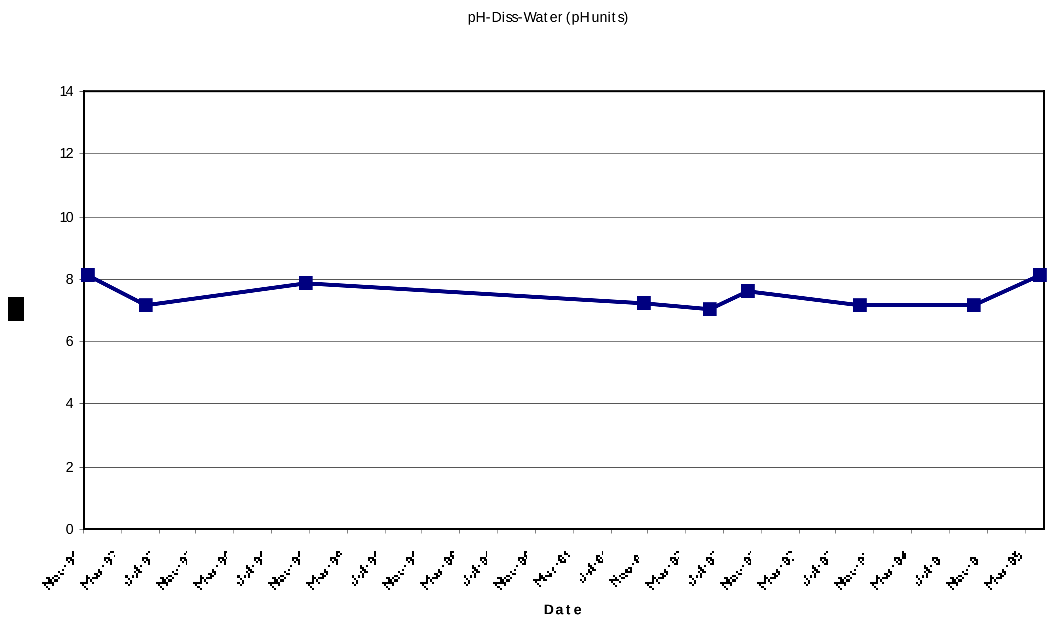

Figure 5. pH values over time at station ZQMWSD1

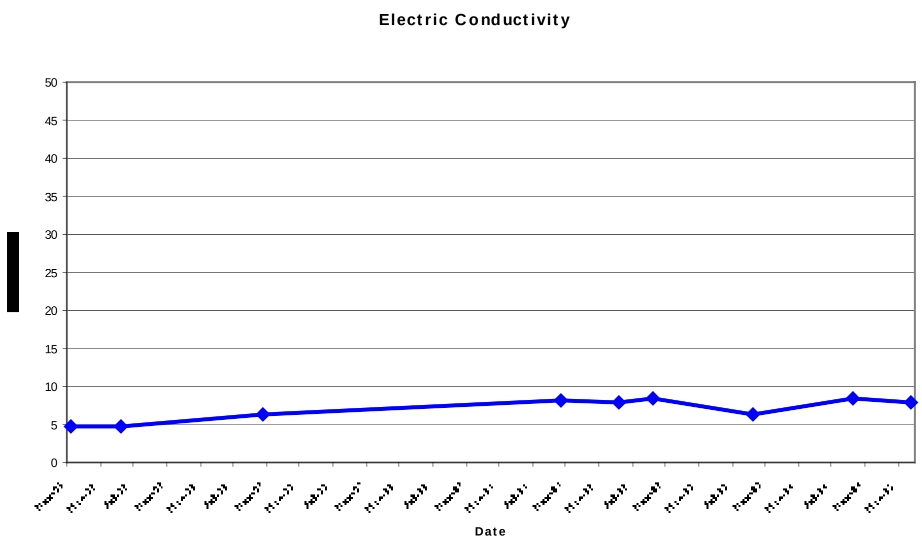

Figure 6. EC values over time at station ZQMWSD1

The EC value is very low and this resembles almost the value of pure rainwater, it is also an indication that the groundwater is very young.

The low concentration of cations, as shown in figure 7, also supports the above statement.

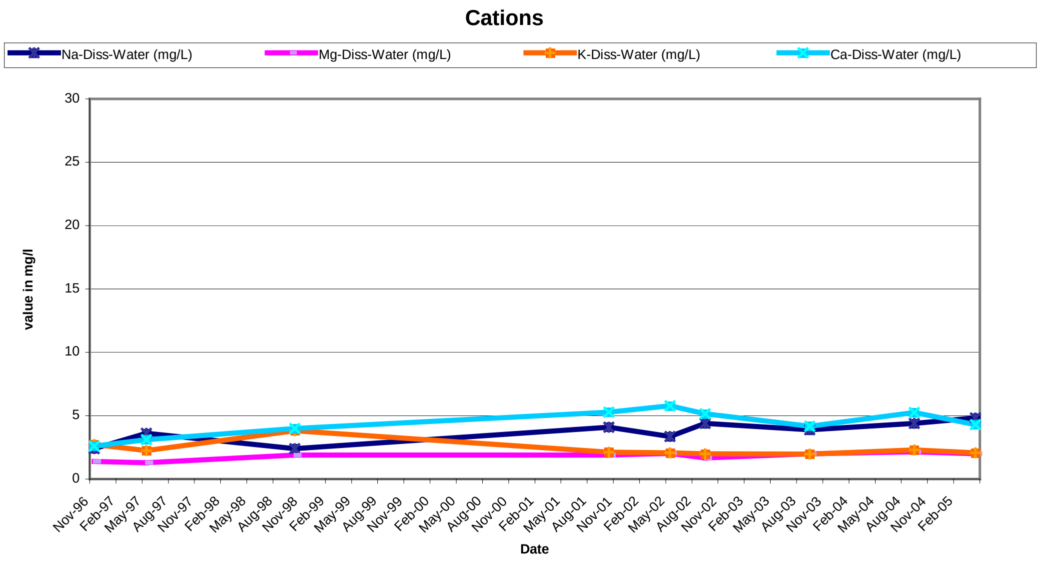

Figure 7. Cation concentration over time at station ZQMWSD1

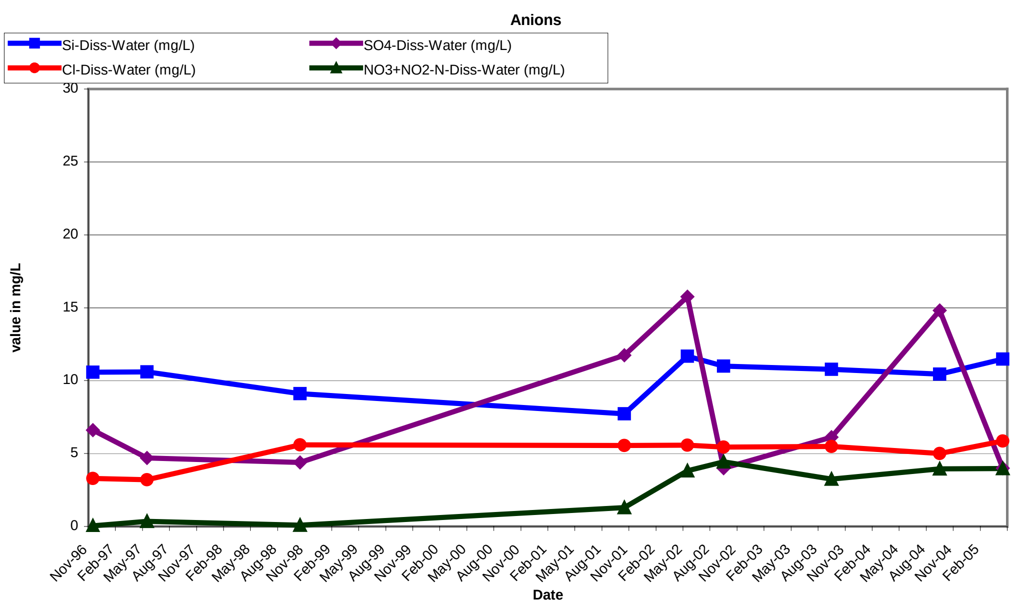

Figure 8. Anion concentration over time at station ZQMWSD1

The concentration of anions changes more over time than the elements shown in previous graphs. A possible reason for this is that samples were taken at different depths and thus resulting in inconsistent values of some elements.

Recharge

Chloride method

The chloride method to determine recharge is a very cheap method for the first time estimate of groundwater recharge and is determined by the equation:

$$\mathbf{R_e = Cl_{rf}/Cl_{gw} * R_f}$$

Where Cl_{rf} = Chloride in rain, Cl_{gw} = Chloride in groundwater and R_f = average annual rainfall.

Table 2. Chloride method: parameter values for Witsand

Chloride in rain (From existing national data)	Chloride in groundwater (median from samples taken on 2004/10/14 at De Beers resource)	Average annual rainfall (Calculated over past 11 years from 1993 to 2004)
1.2 mg/L	5 mg/L	290 mm

∴ Re = 1.2/5 * 290 = 69.6mm

∴ Re = 24 %

5. WATER USE AND MONITORING

Monitoring of water use take place on a monthly basis. Every production borehole is equipped with a flow meter and the monthly readings are recorded in a logbook. Water level monitoring takes place quarterly and during this monitoring the data from the data loggers are also downloaded and the instruments checked for batteries or other errors that might occur. Water quality samples are taken bi-annually for the ZQM-National water quality-monitoring program.

A water user and stakeholder committee consisting of members from the Farming Community, Nature Conservation, Dept of Water Affairs and Dept of Public Works are responsible for the abovementioned actions. A formal meeting is held on a quarterly basis to report on the management of the resource and to address and solve problems that occur with the everyday use of the whole system.

Figure 9 shows a map of the area with the borehole distribution and water use indicated on it. The circled areas are the well fields where abstraction takes place and the arrows indicate the direction and farms to where the water is used.

Figure 9. Map indicating borehole distribution and water use

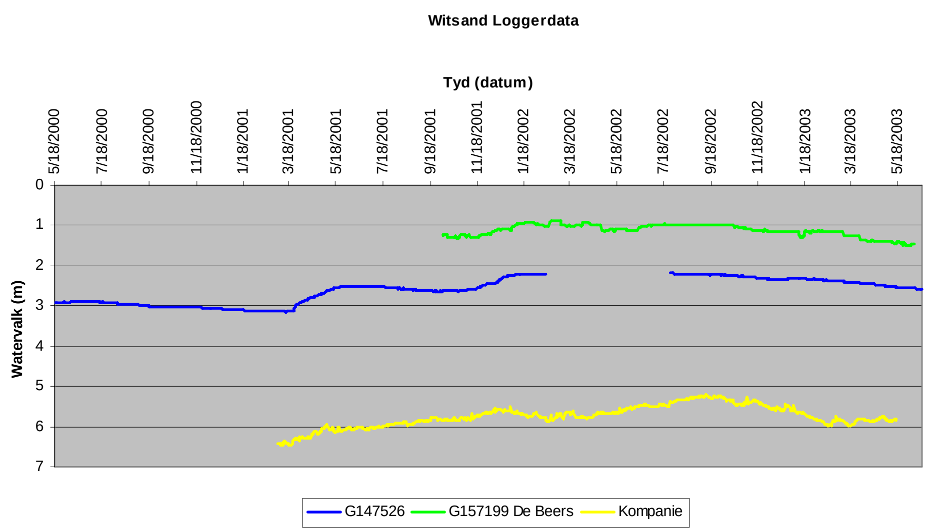

Figure 10. Graph of water levels measured with data loggers

The placement of the data loggers is as such that it will resemble the effect of pumping, but also natural trends in the water levels. At the De Beers and Noordelike Bron the water levels in the Logger holes are not really impacted by abstraction from the aquifer but give a good idea of what is happening with the groundwater state in the well field and immediate surrounding areas. During the last winter months of 2004 the water levels at Kompanie dropped significantly but recovered well during the summer months. The situation of this well field is being closely monitored.

Regarding the water use the following graph (figure 11) will give a good idea of the average monthly water use from the different parts of the resource as indicated by figure 9.

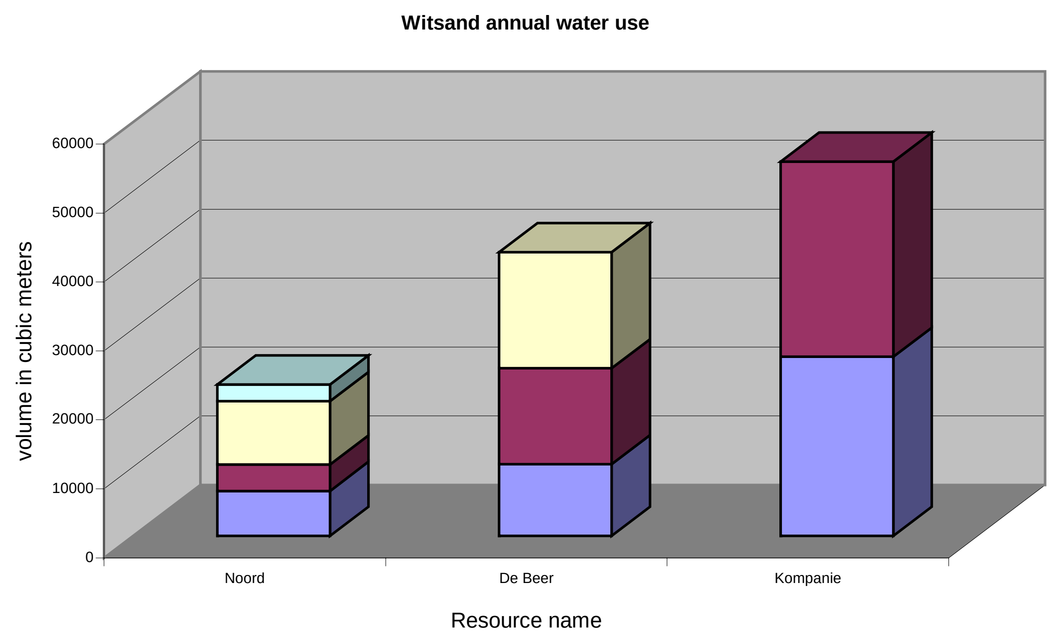

Figure 11. Witsand annual water use

The water use in different parts of the resource as indicated by figure 11 is as follow: The average annual abstraction for the Northern Resource is 21941m^3, for De Beers Resource is 41159m^3 and for Kompanie Resource is 54282m^3. The total annual abstraction form the white dune complex is 117382m^3 for the past six years.

The following table shows the difference between the average water use and recharge over the past ten years. The abstraction value only presents the pumped volume and does not allow for evapotranspiration and other losses.

Table 3. Recharge and abstraction value

Recharge	Abstraction
+ 974 400 m^3/a	-117 382 m^3/a

6. CONCLUSION AND RECOMMENDATIONS

The conclusions that can be derived from this report are that the monitoring in place for water levels are sufficient and the necessary management and structures are in place to ensure the sustainable use of the aquifer.

The level and standard of the water quality monitoring should be improved to build a better database for water quality to aid in better management for the future.

If future developments are considered it is advised that the Northern part of the groundwater resource is targeted, because the largest volume of the abstraction is currently from the two well fields in the Southern part of the resource.